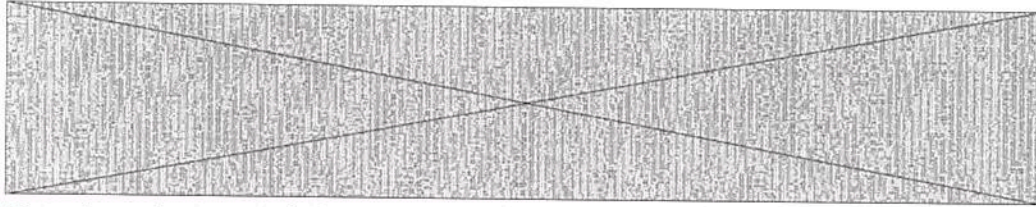


To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Wed 2/19/2014 1:14:27 PM
Subject: Santos-Leon of Abengoa Bioenergy Honored with RFA's 2014 Industry Award



Santos-Leon of Abengoa Bioenergy Honored with RFA's 2014 Industry Award

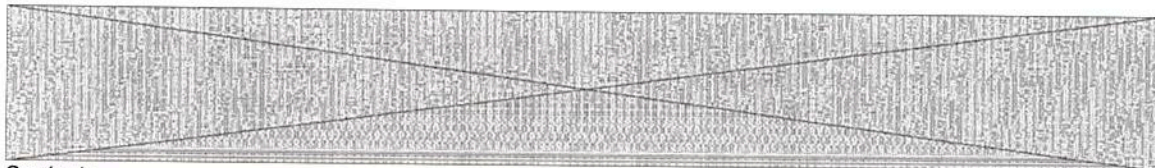
(February 19, 2014) ORLANDO, Fla. — The Renewable Fuels Association's President and CEO Bob Dinneen presented the "RFA 2014 Industry Award" to Gerson Santos-Leon, the executive vice president of Abengoa Bioenergy New Technologies. The award was given at the National Ethanol Conference in Orlando, Fla., in gratitude for the sustained vision, innovation, and devotion to making cellulosic ethanol a commercial success.

"Gerson is truly one of the great pioneers in the cellulosic ethanol industry. His work at the Department of Energy two decades ago helped provide the scientific foundation many companies are relying upon today to move advanced biofuel technologies forward. And his continued leadership over the past 10 years in bringing cellulosic ethanol to commercial success at Abengoa is a testament to his grit, his genius and his creativity," stated Dinneen.

Christopher Standlee, executive vice president at Abengoa Bioenergy Corporation, remarked, "Gerson has dedicated his entire career to the development of advanced and second generation biofuels, as well as the improvement of the first generation ethanol industry. I have had the pleasure of working with him at Abengoa for more than 10 years, and no one is more deserving of this honor."

In addition to his work on research and development at Abengoa Bioenergy New Technologies, Santos-Leon served at the U.S. Department of Energy as the head of their Biofuels Program and received a degree in chemical engineering from the University of Puerto Rico.

Last year's "RFA Industry Award" was awarded to Scott Zaremba, president of Zarco USA Inc., the first petroleum marketer to offer E15. Previous award recipients include Ron and Diane Fagen of Fagen, Inc., three-time RFA Chairman Ron Miller, managing director and co-founder of Prisma Advisors, LLC., and Dave Vander Griend of ICM, Inc.



Contact:

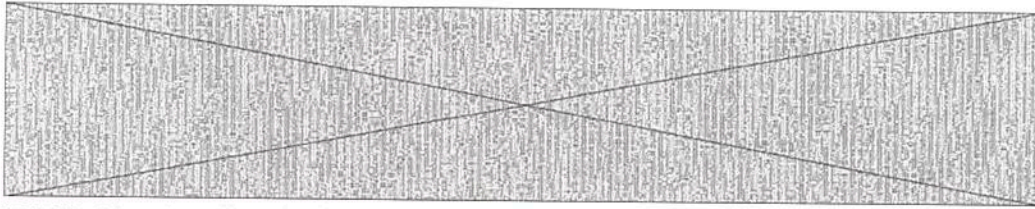
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To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Tue 2/18/2014 1:16:17 PM
Subject: RFA Unveils 2014 Industry Outlook and Pocket Guide



RFA Unveils 2014 Industry Outlook and Pocket Guide

(February 18, 2014) ORLANDO, Fla. — The Renewable Fuels Association released its annual [2014 Ethanol Industry Outlook](#) and [2014 Pocket Guide to Ethanol](#) providing an in-depth look at the current state of the ethanol industry at the National Ethanol Conference in Orlando, Fla.

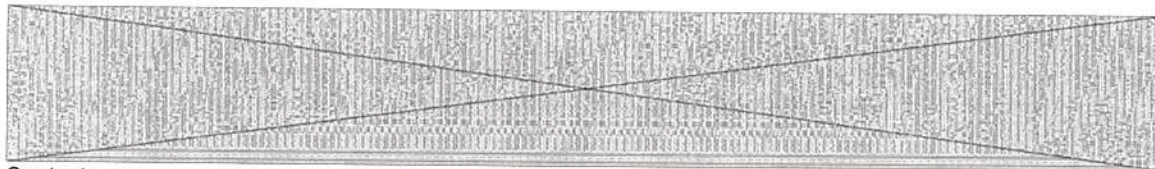
“Last year was a tough year for the industry as misguided attacks on the RFS came from all angles. There is a clear need to educate individuals and policy makers about the goals and successes of the RFS,” explained Bob Dinneen, president and CEO of the Renewable Fuels Association. “The 2014 Ethanol Industry Outlook and 2014 Pocket Guide to Ethanol are easy to understand resources that help explain the unique facets of this vital industry and underline the imminent need to protect the RFS.”

The annual 2014 Ethanol Industry Outlook offers a comprehensive look at the ethanol industry today and is accompanied by the popular Pocket Guide to Ethanol, which presents a succinct industry overview. These publications delve into the Renewable Fuel Standard, investment and innovation in next generation biofuels, expansion of higher level ethanol blends, development of a global marketplace, debunking of the food vs. fuel myth, and an updated map of bio refineries across America.

To download a copy of the Outlook or the Pocket Guide, please visit www.EthanolRFA.org or contact Chris Findlay at 202-289-3835 or cfindlay@ethanolrfa.org to order in bulk.

[View the 2014 Ethanol Industry Outlook](#)

[View the 2014 Pocket Guide to Ethanol](#)



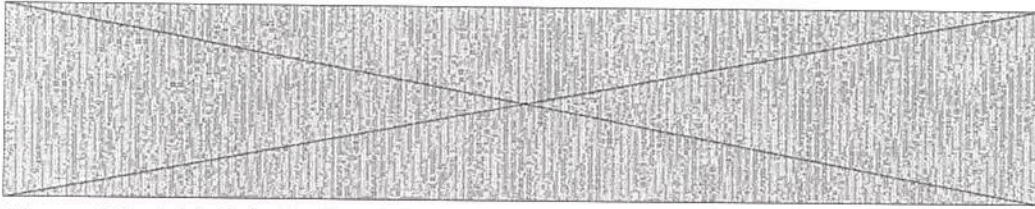
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To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Tue 2/18/2014 1:13:54 PM
Subject: New Study Shows Powerful Impact of Ethanol Industry on Jobs & Energy Independence



New Study Shows Powerful Impact of Ethanol Industry on Jobs & Energy Independence

(February 18, 2014) ORLANDO, Fla. — The Renewable Fuels Association unveiled a new study today by ABF Economics entitled “Contribution of the Ethanol Industry to the Economy of the United States” at the National Ethanol Conference in Orlando, Fla. The study examines the nationwide impact of the ethanol industry in 2013 on job creation, the economy, household income, and foreign oil displacement.

Bob Dinneen, president and CEO of the Renewable Fuels Association, commented on the new study, noting, “Last year we fought, and we continue to fight, against naysayers determined to end the Renewable Fuel Standard. These numbers should silence the opposition as the ethanol industry is clearly helping individuals, families, communities, and our country by creating jobs, displacing oil imports, and contributing to America’s economy.”

The new ABF Economics study found that the 13.3 billion gallons of ethanol produced created 86,503 jobs and sustained an additional 300,277 indirect and induced jobs.

At the national level the ethanol industry contributed \$44 billion to America’s Gross Domestic Product (GDP) while adding \$30.7 billion to household incomes.

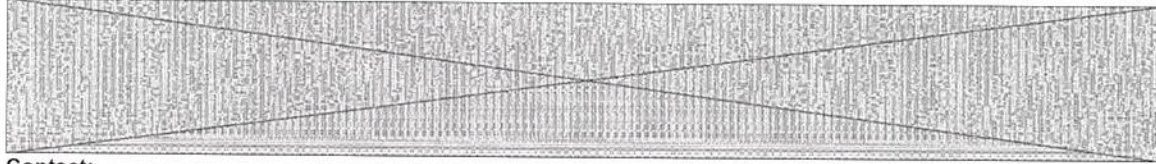
Additionally, the 13.3 billion gallons of ethanol displaced 476 million barrels of imported oil, saving Americans \$48.2 billion in oil imports. That equals roughly 13 percent of last year’s expected crude oil and petroleum imports.

“The ethanol industry continues to make a significant contribution to the economy in terms of job creation, generation of tax revenue, and displacement of imported crude oil. The \$40 billion ethanol producers spent on raw materials, other inputs, and goods and services during 2013 contributed more than \$44 billion to the nation’s GDP and supported a significant number of jobs in all sectors of the economy. The use of ethanol also continues to enhance the nation’s energy independence. The dollars spent on domestically produced ethanol instead of imported crude oil and petroleum products is money that is spent and reinvested in the American economy,” said John Urbanchuck, managing partner of ABF Economics.

The study conducted by ABF Economics, and commissioned by the Renewable Fuels Association, can be found [here](#).

Key findings of the report:

- 86,503 direct jobs
- 300,277 indirect and induced jobs
- \$44 billion contribution to GDP
- \$30.7 billion in household income
- 476 million barrels of imported oil displaced, valued at \$48.2 billion in 2013
- \$8.3 billion paid in federal, state and local taxes



Contact:

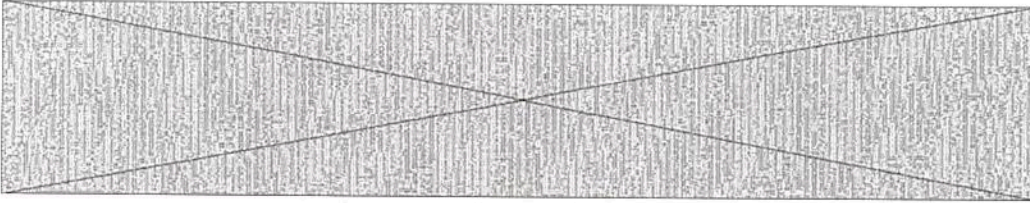
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To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Fri 2/7/2014 7:29:34 PM
Subject: Together Farm Bill and RFS Revitalize Rural America



Together Farm Bill and RFS Revitalize Rural America

(February 7, 2014) WASHINGTON, D.C. — As President Obama signs into law the Agricultural Act of 2014, Bob Dinneen, President and CEO of the Renewable Fuels Association (RFA), commented:

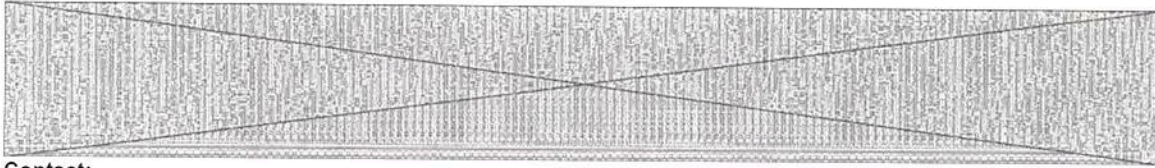
“President Obama and Congress are to be applauded as the Farm Bill of 2014 becomes law. The President is absolutely correct to champion the economic benefits of this legislation on rural America. Creating jobs and economic opportunity is most challenging in rural communities, which is why the President has long supported and appreciated the value of the American biofuels industry.

“Under the Renewable Fuel Standard, the U.S. ethanol industry created and supported over 386,000 jobs in the past year. Forty-six percent of ethanol industry workers earned more than \$75,000 annually while another 45 percent reported making between \$40,000 and \$74,999. Ninety-six percent of workers had health insurance and 92 percent had retirement plans.

“The economic benefits of the RFS are not limited to the rural communities. At the macro level, the RFS is helping Americans coast-to-coast, border-to-border save money by reducing the price of gasoline by an average of \$1.00/gallon in 2012 and 2013. Under the RFS, imports of foreign gasoline dropped an incredible 89 percent from 2007 to 2013 helping this nation become more secure at both the economic and national security levels. The RFS also reduces greenhouse gas emissions by 40-50 percent compared to gasoline.

“To build on the success of the Farm Bill, we call on President Obama and the Environmental Protection Agency to protect the RFS and restore the 2014 conventional ethanol requirement to its statutory level. The President is right to champion rural America and the time to fight for the RFS is right now. If the EPA’s proposal to decrease the conventional ethanol portion of the RFS becomes a reality, rural America will be hit the hardest. Farm income will fall, corn prices will sink, and land value will fall. Much like the Farm Bill, it may be a long and hard fight but we will continue fighting for American farmers, consumers and rural communities.”

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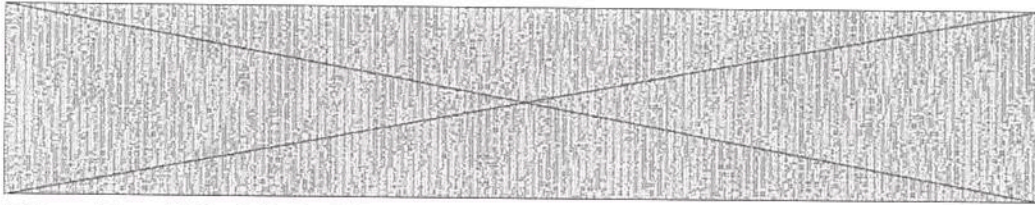
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To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Thur 1/30/2014 6:49:40 PM
Subject: Flex-Fuel Vehicle Makes and Models



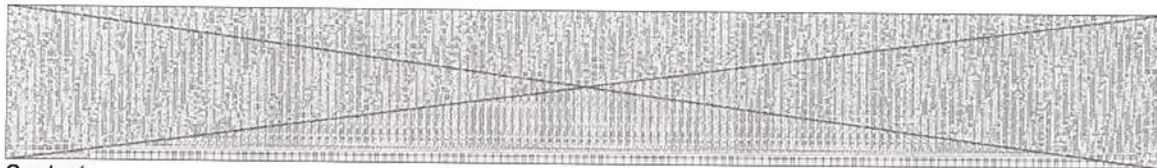
Flex-Fuel Vehicle Makes and Models

(January 30, 2014) WASHINGTON — The Renewable Fuels Association (RFA) has been a leader in the ethanol industry promoting the production and use of flex-fuel vehicles (FFVs) and the expansion and distribution of E85 (85 percent ethanol, 15 percent gasoline). RFA's newly updated [2014 flex-fuel vehicle brochure](#) explains in detail which makes and models are available as FFVs. There are more than 16 million FFVs on the road today and more than 3,200 stations nationwide that offer E85.

"Flex-fuel vehicles come in many different makes, models, shapes and sizes," said Robert White, RFA's director of market development. "I would encourage anyone looking to purchase a new vehicle to consider a flex-fuel vehicle which offers more choices when filling up at the pump."

According to www.E85prices.com/Michigan the average price of E85 in Michigan today is \$2.65, compared to today's average gasoline price of \$3.22. E85 prices dipped as low as \$1.99 today in Lake Odessa, Mich.

E85 stations can easily be located through an app on any [iPhone](#) or [Android](#) system in addition to [Garmin](#) and [TomTom](#) GPS devices. For more information on flex-fuel vehicles and E85 please visit www.ChooseEthanol.com.



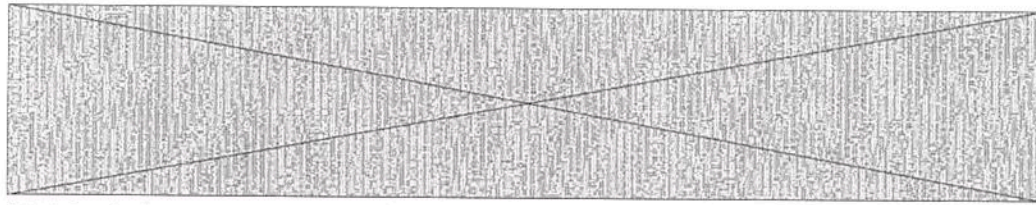
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To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Tue 1/28/2014 8:25:48 PM
Subject: RFA Calls on EPA to Reverse Stance on Proposed 2014 RFS Blending Levels



RFA Calls on EPA to Reverse Stance on Proposed 2014 RFS Blending Levels

(January 28, 2014) WASHINGTON — The Renewable Fuels Association (RFA) submitted comments to the Environmental Protection Agency (EPA) today urging the Agency to reverse its proposal to lower the 2014 Renewable Fuel Standard (RFS) Renewable Volume Obligations (RVOs). EPA has proposed to reduce the RFS from the statutory volume of 18.15 billion gallons (BG) to just 15.21 BG. As part of the cut, EPA is proposing to lower the requirement for renewable fuel (the portion of the RFS for which corn starch ethanol qualifies) from 14.4 BG to 13.01 BG.

In the detailed comments submitted to EPA Administrator Gina McCarthy, RFA President and CEO Bob Dinneen expressed that “RFA is strongly opposed to the proposal to reduce the 2014 RVO for renewable fuel from the statutory level of 14.4 billion gallons to 13.01 billion gallons. We encourage EPA to reconsider its proposal and finalize the 2014 requirement for renewable fuel at 14.4 billion gallons—the level set by Congress.”

Dinneen addressed the impact of the EPA’s proposal on the Renewable Identification Number (RIN) program, explaining, “Had the Agency proposed keeping in place the RVO for renewable fuel at the statutory level of 14.4 billion gallons, the RFS program’s Renewable Identification Number (RIN) market mechanism would have continued to function exactly as intended to ensure that required volumes of renewable fuels are produced and consumed. But by proposing an RVO for renewable fuel that is below the ‘blend wall,’ the proposed rule completely eviscerates the RIN market. In this way, the most significant factor contributing to the so-called ‘blend wall’ in 2014 is *EPA’s proposal itself*. The baffling approach to establishing annual RVOs set forth by EPA results in a circuitous, self-fulfilling prophecy that ultimately defeats the purpose of the RFS.”

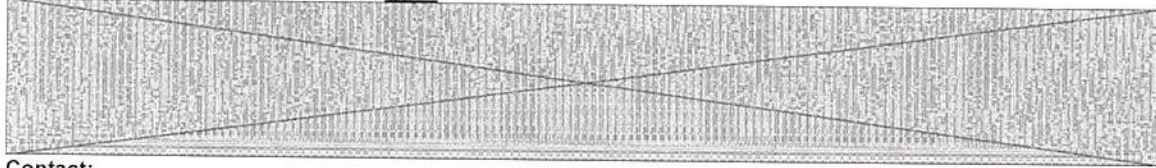
He continued, “Plainly, this is a backward approach to complying with the RFS that belies Congress’s intent. Restoring the efficacy of the RIN mechanism by setting the RVO at 14.4 billion gallons would break this vicious circle and ensure the goals of the RFS are met.”

Dinneen also addressed the EPA’s lack of legal authority to use the so-called “blend wall” as a determinant for setting the RVO for renewable fuel, noting, “The Clean Air Act does not permit the Agency to take into account ‘factors that affect *consumption*’ in determining whether to grant a general waiver based on an ‘inadequate domestic

supply of renewable fuel. Instead, EPA may grant a waiver based on an 'inadequate domestic supply' of 'renewable fuel' only where it finds that the renewable fuel industry lacks the capability to produce the required volumes of renewable fuel, and where there are insufficient carryover RINs available for obligated parties to meet the statutory RVO. The Agency has not made that showing here."

Dinneen concluded, "In the end, the RFS program was designed to force the oil industry to change the status quo—not to perpetuate it. The entire purpose of this program would be subverted if the oil industry is rewarded for its failure to take the steps necessary to ensure that it was capable of distributing, blending, and dispensing the renewable fuel volumes required under the statute."

RFA's comments can be found [here](#).



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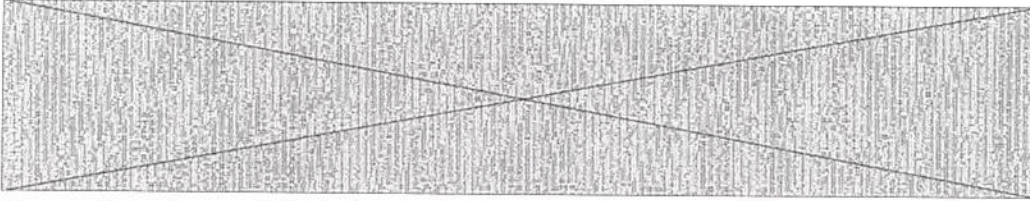
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To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Fri 1/24/2014 4:14:41 PM
Subject: New Study – Statutory 2014 RFS Levels Can be Met Through Increased E85 and E15 Consumption, Carryover RINs



New Study – Statutory 2014 RFS Levels Can be Met Through Increased E85 and E15 Consumption, Carryover RINs

(January 24, 2014) WASHINGTON — A new study by Informa Economics entitled “Analysis of the Potential Use of Biofuels toward the Renewable Fuel Standard in 2014” shows the originally intended Renewable Fuel Standard (RFS) 2014 blending requirements can be reached through expanded consumption of E85 and E15, as well as judicious use of carryover RIN credits. The study clearly demonstrates why the Environmental Protection Agency’s proposal to reduce RFS blending requirements is unnecessary and imprudent.

Using empirical data from 2013, the study shows that E85 sales volumes respond strongly to changes in RIN prices. This demonstrates the RFS program is working exactly as intended to drive expanded consumption of biofuels above the so-called E10 “blend wall.” The study finds, “It is possible for all statutory components and allocations within the Renewable Fuel Standard to be met in 2014, after adjustments have been made for a waiver of a large majority of the Cellulosic Biofuel Standard.”

The Informa analysis was commissioned by the Renewable Fuels Association and Iowa Corn Promotion Board. It will be used to support the groups’ comments to EPA on its proposed rule for 2014 RFS blending requirements.

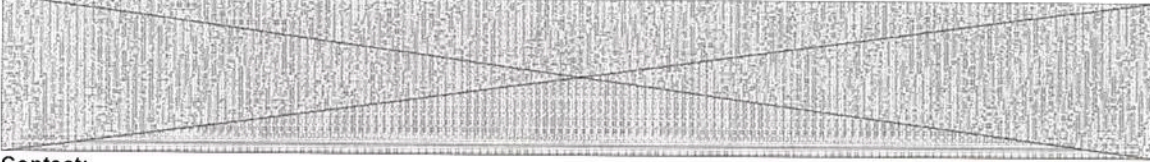
The study takes a closer look at likely consumption, finding that ethanol consumption in 2014 could be at least 13.7 billion gallons, compared to the EPA’s assumption of 13.0 billion gallons. It points toward E85 as a major contributor, stating, “E85 accounts for most of the potential for expanded consumption.” And continues, “The increase could be even larger if E85 is priced at a sustained discount to gasoline (on an energy-equivalent basis), as the consumer response could be stronger than implied by historical data, since discounts have been transitory in the past.”

“This study is further proof that the so-called ‘blend wall’ can be easily scaled if the RFS is allowed to work as intended,” said Bob Dinneen, President and CEO of the Renewable Fuels Association. “As I have said time and time again, the RIN mechanism is the tool to drive innovation and infrastructure to accommodate higher ethanol blends like E85 and E15. There is absolutely no need to reduce or repeal the RFS. It is working.”

Contact:

"We hope that this study further emphasizes that the EPA decision to lower the RVO just doesn't make sense," said Roger Zylstra, a farmer from central Iowa and current president of the Iowa Corn Growers Association. "As a corn grower, I know we have the science and the production to back up the current RFS. It is working and we need to move forward, not backward on our energy security."

The Informa Analysis can be found [here](#).



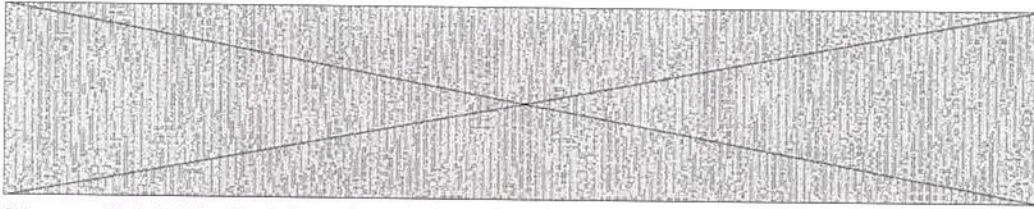
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To: Larson, Robert[larson.robert@epa.gov]
From: Dawn Moore
Sent: Thur 1/23/2014 4:31:44 PM
Subject: New CARD Analysis: RFS and RIN Credits Decrease—Not Increase—Gas Prices



New CARD Analysis: RFS and RIN Credits Decrease—Not Increase—Gas Prices

(January 23, 2014) WASHINGTON — A new independent analysis from the Center for Agricultural and Rural Development (CARD) at Iowa State University found that ethanol expansion under the Renewable Fuel Standard (RFS) program reduces gas prices and suggests that Congress and the Administration have been misled about the impacts of RIN credits on retail gas prices. Partially in response to the notion that RINs affect retail gas prices, the Environmental Protection Agency recently issued a proposed rule that would lower the blending requirements for conventional ethanol from 14.4 billion gallons to 13.01 billion gallons.

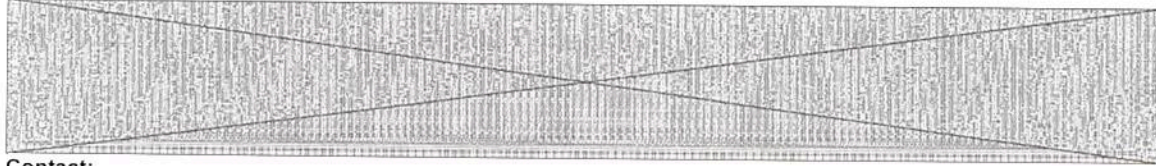
The analysis "Impact of Increased Ethanol Mandates on Prices at the Pump," by Professors Bruce Babcock and Sebastien Pouliot, concludes that RFS policies decrease gas prices and should not be a reason to reevaluate or revamp the RFS. The paper shows that as RIN prices increase, the retail prices for both E85 and E10 decrease. It states, "As we demonstrate here, one of the costs that does not need to be considered is an increase in the pump price of fuel, because we show that the most likely outcome from increasing ethanol mandates is a drop in pump prices, not an increase."

According to the analysis, "Our results should reassure those in Congress and the Administration who are worried that following the RFS commitment to expanding the use of renewable fuels will result in sharply higher fuel prices for consumers. There may be sound policy reasons that could justify Congress revisiting the RFS. However, concern about higher pump prices for consumers is not one of them."

Bob Dinneen, President and CEO of the Renewable Fuels Association, weighed in on the analysis, stating, "Many ethanol opponents have used higher RIN prices to scare people into believing that gas prices will rise if the RFS remains in place. This study puts that argument to bed once and for all. The RFS is working as intended. It's time for our country's leaders to take a good hard look at ethanol and realize the positive impact it has on our environment, our economy, and our consumers. The new CARD analysis takes the gas price fear out of the equation."

Babcock and Pouliot also point out that Congress should look at the cost and benefit of renewable fuels as a whole instead of focusing specifically on the concerns of biofuels opponents whose motivations are often driven by their bottom line.

The analysis states, "Other arguments often put forth by biofuel opponents concerning significant impacts of expanded biofuel production on consumer food prices and the lack of ability to consume quantities of ethanol beyond E10 similarly lack a solid economic foundation. The reason the oil industry and much of the livestock industry have joined forces against biofuels is one of simple industry economics: their industries would benefit from cheap corn and reduced competition from ethanol. Rather than taking sides with different industry groups in this policy debate, Congress and the Administration should focus on whether the benefits of increasing renewable fuels by reducing fossil fuels are worth the costs. If they are, then support for renewable fuels should not be abandoned."



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To: John DeCicco[decicco@umich.edu]; Betty Taylor[btaylor@crcao.org]
Cc: Anderson, James (J.E.)[jander63@ford.com]; Camobreco, Vincent[Camobreco.Vincent@epa.gov]; Cooper, Geoff[GCooper@ethanolrfa.org]; Courtis, John[jcourtis@arb.ca.gov]; Duffield, James[jduffield@oce.usda.gov]; Duncan, Marvin[mduncan@oce.usda.gov]; Farenback-Brateman, Jeff[j.h.farenback-brateman@exxonmobil.com]; H. Chul Kim[hkim41@ford.com]; Heirigs, Phil[phez@chevron.com]; Katzenstein, Aaron[AKatzenstein@aqmd.gov]; Larson, Robert[larson.robert@epa.gov]; Lax, David[lax@api.org]; Maclean, Heather[hmaclean@ecf.utoronto.ca]; Marelli, Luisa[luisa.marelli@jrc.ec.europa.eu]; Martin, Jeremy I.[JMartin@ucsusa.org]; McCormack, Derek[Derek.McCormack@nrcan-rncan.gc.ca]; Natarajan, Mani[mnatarajan@marathonpetroleum.com]; Rose, Ken[ken.rose@concaawe.org]; Wang, Michael Quanlu[mqwang@anl.gov]; Morel, Gilles[gillesmorel@canadianfuels.ca]; kent.hoekman@dri.edu[kent.hoekman@dri.edu]; Brent Bailey[bkbailey@crcao.org]; Jan Tucker[Jantucker@crcao.org]
From: Don Scott
Sent: Tue 12/3/2013 7:43:30 PM
Subject: RE: CRC LCA Workshop Revised Summary

I think John's suggestion is balanced if folks want to go with that. Though, I don't really see the imbalance in Kent's drafted language either. If this remains a point of contention, perhaps all the opinions on policy should be left out. That would mean leaving the first two sentences and striking the last three in that bullet point.

From: John DeCicco [mailto:decicco@umich.edu]
Sent: Tuesday, December 03, 2013 7:59 AM
To: Betty Taylor
Cc: Anderson, James (J.E.); Camobreco, Vincent; Cooper, Geoff; Courtis, John; Duffield, James; Duncan, Marvin; Farenback-Brateman, Jeff; H. Chul Kim; Heirigs, Phil; Katzenstein, Aaron; Larson, Robert; Lax, David; Maclean, Heather; Marelli, Luisa; Martin, Jeremy I.; McCormack, Derek; Natarajan, Mani; Rose, Ken; Don Scott; Wang, Michael Quanlu; Morel, Gilles; kent.hoekman@dri.edu; Brent Bailey; Jan Tucker
Subject: Re: CRC LCA Workshop Revised Summary

Hi all,

Sorry, but that's not quite there for me. The ending sentences of the first bullet on p. 14 both capture only the positive spin on LCA uncertainties. That, my friends, is a policy perspective on the state of the science. The policy positions consist of the statements about the "need and benefits of moving forward with LCA regulations" and that the uncertainties "should not be a reason for inaction." Those are not scientific conclusions, but rather opinions based on one interpretation of the degree of uncertainty in LCA. I don't object to such perspectives per se, but they must be balanced with an opposite perspective.

Here is my suggested modification to the last part of the first bullet:

Some participants expressed the need and benefits of moving forward with LCA regulations, even though significant uncertainties may exist. Others felt that the extent of uncertainty involved in LCA raises questions regarding its suitability as a compliance method for fuels regulation.

Thanks,

John

On Tue, Dec 3, 2013 at 8:29 AM, Betty Taylor <btaylor@crcao.org> wrote:

Dear LCA Organizing Committee Members,

Attached is the updated LCA Workshop Summary based on the consensus developed during the November 26th telecon. If there are no further comments we plan to post this version on the CRC Website later this week. We thank you one and all for your contributions to the workshop.

Best regards,

Betty Taylor

CRC Correspondence (not for public distribution)

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To: Betty Taylor[bttaylor@crcao.org]; Anderson, James (J.E.)[jander63@ford.com]; Camobreco, Vincent[Camobreco.Vincent@epa.gov]; Cooper, Geoff[GCooper@ethanolrfa.org]; Courtis, John[jcourtis@arb.ca.gov]; DeCicco, John M.[DeCicco@umich.edu]; Duffield, James[jduffield@oce.usda.gov]; Duncan, Marvin[mduncan@oce.usda.gov]; Farenback-Brateman, Jeff[j.h.farenback-brateman@exxonmobil.com]; H. Chul Kim[hkim41@ford.com]; Heirigs, Phil[phez@chevron.com]; Katzenstein, Aaron[AKatzenstein@aqmd.gov]; Larson, Robert[larson.robert@epa.gov]; Lax, David [lax@api.org]; Maclean, Heather[hmaclean@ecf.utoronto.ca]; Marelli, Luisa[luisa.marelli@jrc.ec.europa.eu]; Martin, Jeremy I.[JMartin@ucsusa.org]; McCormack, Derek[Derek.McCormack@NRCan-RNCan.gc.ca]; Natarajan, Mani[mnatarajan@marathonpetroleum.com]; Rose, Ken[ken.rose@concowe.org]; Wang, Michael Quanlu[mqwang@anl.gov]
Cc: Brent Bailey[bkbailey@crcao.org]; Jan Tucker[Jantucker@crcao.org]; kent.hoekman@dri.edu[kent.hoekman@dri.edu]; Morel, Gilles[gillesmorel@canadianfuels.ca]
From: Don Scott
Sent: Thur 11/21/2013 9:23:21 PM
Subject: RE: Summary Report of CRC 2013 LCA Workshop (BALLOT/POLL)
CRC LCA Workshop Summary v2 DS.docx

I found it most convenient to append minor suggestions to the attached version of the draft. I hope this is helpful.

Don Scott, PE

Director of Sustainability

National Biodiesel Board

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From: Betty Taylor [mailto:bttaylor@crcao.org]
Sent: Monday, November 18, 2013 3:13 PM
To: Anderson, James (J.E.); Camobreco, Vincent; Cooper, Geoff; Courtis, John; DeCicco, John M.; Duffield, James; Duncan, Marvin; Farenback-Brateman, Jeff; H. Chul Kim; Heirigs, Phil; Katzenstein, Aaron; Larson, Robert; Lax, David ; Maclean, Heather; Marelli, Luisa; Martin, Jeremy I.; McCormack, Derek; Natarajan, Mani; Rose, Ken; Don Scott; Wang, Michael Quanlu
Cc: Brent Bailey; Jan Tucker; kent.hoekman@dri.edu; Morel, Gilles
Subject: Summary Report of CRC 2013 LCA Workshop (BALLOT/POLL)

Dear LCA Organizing Committee Members,

Attached for your review and approval is the Summary Report of the CRC 2013 LCA Workshop prepared by our Open Forum Session Chair, Kent Hoekman.

Please indicate your approval of this summary by email on the ballot below by Friday **November 22, 2013**. If we do not receive your ballot by November 22nd, we may assume your approval and move forward with this action unless you request additional time.

I would also like to set up a follow-up conference call to fully consider any comments received.

Please mark your availability via Doodle Poll by clicking [here](#) no later than close of business Wednesday, **November 20, 2013**. If you have difficulty reaching Doodle Poll through your server please mark your availability in the box below.

I will send an email with the date and time most selected Thursday morning.

Dates 11:00 AM ET 1:00 PM ET

Fri. 11/22
Mon. 11/25
Tues. 11/26
Mon. 12/2
Tues. 12/3
Wed. 12/4
Thurs. 12/5
Fri. 12/6

Yours truly,

Betty Taylor

******CRC BALLOT -- Please return ballot no later than Friday, November 22, 2013******

I approve of the Summary Report of the CRC 2013 LCA Workshop _____

I do not approve _____

Name: _____

Company:

Comments:

Betty Taylor

CRC Correspondence (not for public distribution)

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Summary of

CRC Workshop on Life Cycle Analysis of Transportation Fuels

Argonne National Laboratory
October 15-17, 2013

On October 15-17, 2013, the Coordinating Research Council (CRC) hosted a workshop at Argonne National Laboratory outside of Chicago, Illinois, which focused on technical issues associated with life cycle analysis (LCA) of transportation fuels, with particular emphasis on biofuels. The workshop was co-sponsored by API, Argonne National Laboratory, CONCAWE, Canadian Fuels Association, National Biodiesel Board, Renewable Fuels Association, South Coast Air Quality Management District, US Department of Agriculture, US Department of Energy, and the University of Michigan Energy Institute.

The following goals were established for the workshop:

- Outline technical needs arising out of policy actions and the ability of LCA to meet those needs.
- Identify research results and activities that have come to light in the past two years that have helped to close data gaps previously outlined as outstanding issues.
- Identify data gaps, areas of uncertainties, validation/verification, model transparency, and data quality issues.
- Establish priorities for directed research to narrow knowledge gaps and gather experts' opinions on where scarce research dollars would best be spent.

More than 100 representatives from government, industry, academia, and NGOs attended the workshop. Twenty presentations were given, organized into four Technical Sessions. Additionally, an Opening Session provided background information about CRC, and gave context for this 3rd LCA Workshop by summarizing the previous two workshops. Also, two Open Forum Discussion Sessions were held to help identify high-priority issues related to LCA of transportation fuels, and engage in further discussion of these issues.

This summary report highlights the topics discussed in each session as well as the knowledge gaps identified by the speakers, the session chairs, and through interaction with the workshop participants. Most of the workshop presentations are available for download from the CRC website.¹

Opening Session: Background of CRC LCA Workshops

Chairpersons: Brent Bailey (CRC) and Phil Heirigs (Chevron)

Brent Bailey (CRC) provided a brief history of CRC. Since its establishment as an independent organization in 1942, CRC has directed cooperative scientific research among industry (primarily the automobile and petroleum industries) and governmental bodies to develop optimum combinations of

¹ See <http://www.crcao.org/workshops/LCA%20October%202013/LCAindex2013.html>

fuels, lubricants, and the equipment in which they are used. Environmental research began later, following establishment of CRC's Air Pollution Research Advisory Committee (APRAC) in 1968. Since the 1980's, CRC has organized and conducted a number of large experimental programs aimed at understanding the relationships between fuel composition and emissions, and the impact of these emissions upon air quality. The current activities regarding LCA of transportation fuels falls within the scope of the CRC charter, and the workshop follows the historical pattern of broad participation of stakeholders in CRC activities.

Phil Heirigs (Chevron) provided background information to explain CRC's current interest in LCA. Initial legislative/regulatory activities by the California Air Resources Board (CARB) began in 2007, calling for a 10% reduction in the carbon intensity (CI) of transportation fuels by 2020, measured on a full fuel cycle basis. Shortly thereafter, the US Congress established volumetric and greenhouse gas (GHG) reduction targets for renewable fuels, with the GHG emissions related to the full fuel lifecycle. In 2009, the EU adopted directives regarding renewable fuels, with determination of the GHG emissions impacts to consider life cycle aspects. In response to these legislative/regulatory actions, different assessment tools and assumptions have been developed and applied, resulting in different outcomes. Understanding these differences was the primary motivation for CRC's initial LCA Workshop in 2009.

Mr. Heirigs reviewed the important conclusions from the 1st and 2nd workshops, and he noted that this 3rd LCA workshop was intended to continue exploration of the LCA issues identified previously, including LCA methodology development and applications, iLUC assessments, advancements in LCA of biofuels, and LCA of petroleum-derived and other alternative fuels.

Session 1: Regulatory Environment/ New Policies Driving LCA Pathways and Methodologies

Chairpersons: Jim Duffield (USDA), Bob Larson (US EPA), David Lax (API), and Mani Natarajan (Marathon Petroleum Co.)

The workshop's first session dealt with the regulatory framework and policy needs that drive much of the activity to improve and expand LCA modeling efforts. International regulatory perspectives were provided by Michael Rensing of the British Columbia (BC) Ministry of Energy and Mines, and by Luisa Marelli from the European Commission Joint Research Centre (EC-JRC). US EPA was unable to attend due to government travel restrictions associated with a government shutdown. CARB was also unable to attend, although presentation materials prepared by John Courtis were submitted, and are summarized below.

Highlights and Key Learnings

John Courtis (CARB) planned to provide an update on California's Low Carbon Fuel Standard (LCFS), which requires a 10% reduction of carbon intensity (CI) of the entire transportation fuel pool by 2020. CI, expressed as g CO_{2-eq}/MJ, is the measure of GHG emissions associated with producing, transporting, and consuming a particular fuel derived from a particular pathway. GHG emissions associated with indirect land use change (iLUC) are included in CARB's determination of CI for each biofuel pathway. There are now approximately 100 regulated parties (fuel suppliers) in California who are reporting and complying with the LCFS regulations. CARB continues to add new fuel pathways into the regulatory system, and is currently re-examining iLUC values for corn ethanol, sugarcane ethanol, and soy

biodiesel. Overall, CARB believes the LCFS regulations are working well, and are having an indiscernible impact on fuel prices.

Michael Rensing (BC Ministry of Energy and Mines) described low carbon fuel requirements in Canada, with an emphasis on the BC situation. Throughout Canada, the GHGenius model is employed to assess LCA of transportation fuels, although different versions of the model are used by different Provinces. In BC, a 10% reduction in CI is required by 2020. At present, there is no consideration of iLUC in this determination. Credits or debits are calculated for various fuels that could be used in BC, although at present, only ethanol and biodiesel are commonly available. To achieve required future GHG reductions, other liquid fuels will need to be introduced, such as hydrogenation-derived renewable diesel (HDRD), and possibly alternatives such as natural gas and electricity.

Luisa Marelli (EC-JRC) presented an overview of European legislation and policy regarding LCA of biofuels. Two policy directives drive renewable fuel and sustainability requirements for the EU: the Renewable Energy Directive (RED; Directive 2009/28/EC) and the Fuel Quality Directive (FQD; Directive 98/70/EC). The RED requires that renewable fuels comprise 10% of all transport fuel within the EU; the FQD requires a 10% reduction in GHG intensity of biofuels/alternative fuels, and requires a minimum life cycle GHG savings (compared to fossil baseline) of 35% -- increasing to 60% by 2018. The JRC has developed an extensive (and recently updated) database of GHG emissions for many biofuel pathways within the European context. Although fuel providers are encouraged to declare actual emissions associated with their specific pathway, they may still choose to use established, default values. The ability to mix default values for some parts and actual values for other parts of the fuel pathway in question creates the possibility of over-estimating the GHG reduction benefits for some pathways. Major enhancements incorporated in the recent JRC update include the following:

- Addition of new fuel pathways (ethanol from barley and rye; FAME from coconut oil, jatropha, and waste cooking oil; hydrotreated vegetable oil; biomethane; and lignocellulosic fuels)
- Application of a new European electric energy mix (based on EU27 rather than EU15)
- Co-product allocation for bioliquids that are used to generate heat and electric power
- Development of an improved method for quantifying soil N₂O emissions associated with cultivation of biofuel feedstocks. (This new N₂O method was described in greater detail in a later presentation by Robert Edwards of JRC.)

At present, only direct emissions from production of the biofuels are considered in determining GHG reductions for biofuels. However, EU legislation has introduced a number of objectives that limit the amount of land-based biofuels that can be used, and that encourage development of advanced biofuels. Meanwhile, the EC continues to study the issue of iLUC emissions, and proposals have been drafted to incorporate iLUC requirements in the future. Preliminary iLUC values determined from application of the IFPRI-MIRAGE model for European fuel pathways are 12, 13, and 55 g CO_{2-eq}/MJ for grain-derived, sugar-derived, and vegetable oil-derived crops, respectively.

Summary, Information Gaps and Data Needs – Session 1 highlighted the regulatory advancements being made in different regions. There remains a lack of harmonization throughout different jurisdictions in the areas of LCA definition and application. Although there is increased awareness of iLUC theory and quantification, at present, it is only being applied in a regulatory sense within the US. However, the EU

has been studying iLUC for some time, and is developing methodologies to potentially incorporate it into future regulations. Further efforts are still required to work towards a more uniform understanding of LCA model structures and the underlying data sources.

Session 2: LCA Methodology Development, Gaps and Uncertainties

Chairpersons: John DeCicco (U. Michigan), Chul Kim (Ford), Ken Rose (CONCAWE), and Geoff Cooper (RFA)

Session 2 provided various perspectives and updates about LCA model structures and operations. Key differences in model inputs and assumptions were identified, and the impacts they have on model outcomes were discussed. The session began with Don O'Connor of (S&T)² who discussed model differences and variabilities, followed by Mike Griffin of Carnegie Mellon University (CMU) who discussed the issue of uncertainty, as applied to LCA. Bo Weidema of 2.0 LCA Consultants presented updates to European LCA methodologies, and Brian Murray of Duke University described the linkage between commodity markets and land use. The session concluded with Michael Wang of Argonne who presented updates to the widely-used US model called GREET.

Highlights and Key Learnings

Don O'Connor (S&T)² discussed the research project, CRC-E-102, that he is currently conducting under sponsorship of CRC. The objectives of this study are to quantify sources of uncertainty and variability in selected LCA models being used to regulate fuels, and to define the factors responsible for major differences in model outputs. Four LCA models are included:

1. BioGrace, as being used in the EU's RED program
2. US EPA's modeling system as being used in the RFS program
3. GREET, as being used in CARB's LCFS program
4. GHGenius, as being used in BC's LCFS program and Alberta's RFS program

With each model, six fuel pathways are being evaluated: (1) gasoline/diesel from petroleum, (2) ethanol from corn, (3) ethanol from sugarcane, (4) cellulosic ethanol, (5) biodiesel/renewable diesel from soybeans, and (6) natural gas. Only direct GHG emissions are considered in this evaluation – no iLUC. Also, to allow for more straightforward comparisons in a common format, some minor modifications were made, such as defining the same modeling year and consistently using lower heating values (LHV) as the basis for energy content.

A series of results tables were presented to compare the CI values determined by each model for each stage of the life cycle (e.g. feedstock production, feedstock transport, and fuel production) as well as co-product allocation method and credits (where applicable). Several large differences in model outcomes were identified. For example, the overall corn ethanol CI value estimated by BioGrace is quite low, because of the large co-product credit for electrical power generation assumed in European ethanol production plants. On the other hand, BioGrace predicts the largest CI value for soybean-derived biodiesel because of high feedstock transportation emissions, resulting from shipping of soybeans from Brazil to Europe. The models gave quite different results for cellulosic ethanol, with GHGenius predicting the highest CI value, largely due to incorporation of more process chemicals used in the conversion of cellulosic feedstocks into ethanol. In summary, O'Connor concluded that there is significant variability

among the models studied, and that the drivers of this variability are real – not just model “errors.” The final report for this CRC-E-102 project will become available in the near future.

Mike Griffin (Carnegie Mellon Univ.) discussed uncertainty in LCA, and the implications this can have with respect to policy decisions. He differentiated two categories of uncertainty: (1) parametric (uncertainty about the value of empirical quantities) and (2) model (uncertainty about model functional form). Empirical quantities represent properties of the real world, which in principle, can be measured. Griffin described the ISO 14044 standard, which defines uncertainty analysis, and he recommended that this be applied to LCA studies. He presented LCA examples producing single point estimate results, ranges of results, and probability distribution results. Probability distributions are most useful in providing insights regarding the likelihood of achieving policy goals, and in understanding the robustness of the policy design.

Bo Weidema (2.0 LCA Consultants) discussed LCA methodology development in the EU, including efforts to deal with iLUC. The recent Product Environmental Footprint (PEF) guidelines from the EC call for consequential LCA modeling, but exclude iLUC. To support this modeling, an updated version of the Ecoinvent database has been developed. This now allows for direct comparison of consequential and attributional modeling based upon the same unit processes. Such a comparison highlights large GHG differences in the area of land use, with the consequential result being much higher than the attributional result. Further advancements include development of an updated version of ExioBase, which is a global Input/Output Table (IOT) that includes both physical and monetary parameters. (The earlier version was strictly a monetary database.) Use of ExioBase v2 in combination with Ecoinvent v3 provides a complete consequential modeling system that is consistent with the ISO 14040/44/49 standards. Weidema concluded that there has been a significant degree of harmonization in European LCA modeling principles, but that the topic of iLUC remains as an unresolved and controversial subject.

Brian Murray (Duke Univ.) described recent work focused on assessing iLUC of biofuels at various spatial scales. In general, the potential for iLUC effects increases as the geographic scale increases from regional to global. Several examples were presented to show the importance of integrating LCA with modeling of commodity markets and LUC. Through modeling exercises it was shown that the US RFS2 Program is effective in reducing net GHG emissions in the US, although global emissions may be neutral, or even increase slightly under some conditions. Results are sensitive to crop yields and other iLUC assumptions. From another study it was shown that having both the RFS2 Program and a subsidy for corn ethanol is duplicative. Murray concluded that the topic of iLUC effects from biofuel policies is too important to ignore, and it should be addressed through explicit connections between biofuel demand, commodity markets, and land use.

Michael Wang (Argonne NL) discussed recent updates to the GREET model, culminating in release of version GREET1_2013. Major changes in this new version include the following:

- Petroleum refinery efficiency is expressed as a function of crude quality and refinery complexity
- Updated efficiencies and emission factors are included for US power plants
- Updated methane leakage data are included for natural gas fuel pathways
- Marine fuel pathways and commercial vessel operations have been added
- Updated iLUC emissions are included as determined using the Carbon Calculator for Land Use Change (CCLUB) component in GREET

- Updated tailpipe emission factors for light-duty vehicles are incorporated from EPA's MOVES model

Wang presented several examples in which the new GREET1_2013 model was applied to investigate LCA sensitivities and results. For example, the GHG benefit of CNG vehicles compared to conventional gasoline vehicles depends upon methane leakage rates and assumed efficiencies of the CNG vehicles. Similarly, the GHG benefits of electric vehicles (EVs) depend upon the efficiency of the power plants being used. Use of EVs also has implications for other air pollutants. For example, Wang stated that battery electric vehicles (BEVs) charged by the average US electricity mix "are only 40% likely to achieve NOx emissions reduction, and are about 100% likely to increase PM₁₀ emissions."

Use of GREET to compare LCA GHG emissions of different US bioethanol pathways was discussed. Corn ethanol was determined to have a CI of ~65 g CO_{2-eq}/MJ (including iLUC) while sugarcane ethanol's CI was approximately 45 g CO_{2-eq}/MJ (including iLUC). The calculated CI values of ethanol from corn stover, switchgrass, and miscanthus were all much lower. Wang pointed out that N₂O emissions associated with crop growth are very significant (responsible for up to ¼ of GHG emissions for corn ethanol) but continue to have high uncertainty.

Summary, Information Gaps and Data Needs – Session 2 highlighted several areas of methodological differences, uncertainties and variabilities in application of LCA models. These differences can significantly influence the final predicted CI of a particular fuel. Based upon systematic comparisons of various modeling approaches, the underlying reasons for these differences are becoming better understood. Most important are real differences in model input assumptions – not simply model formulation errors. Further work could help narrow the range of uncertainties in some inputs. However, significant differences remain in model type (consequential vs. attributional), co-product allocation method, time period, geographic areas, and other aspects. Because different models serve different purposes, it seems unlikely (and even undesirable) to force convergence to a single "best modeling approach." However, it is important for each approach to be fully transparent with respect to input assumptions, supporting databases, and modeling methodologies used. Also, more efforts should be taken to systematically determine uncertainties in modeling results, and to report distributions of results rather than single point values.

Session 3: Advances in LCA of Biofuels

Chairpersons: Jim Anderson (Ford), Jeff Farenback-Brateman (ExxonMobil), Luisa Marelli (JRC), Mani Natarajan (Marathon Petroleum Co.), and Don Scott (NBB)

Session 3 was focused on recent advances in LCA of biofuels, with emphasis on improved LUC modeling through use of updated agro-economic datasets and model structures. Additional topics covered included collaboration/harmonization among models and modelers, efforts to establish sustainability criteria for bioenergy, and advancements in determining N₂O emission factors.

Highlights and Key Learnings:

Wally Tyner (Purdue Univ.) discussed numerous recent changes made to the Global Trade and Analysis Project (GTAP) modeling framework and database, and implications this has with respect to LCA of biofuels. Overall, the underlying databases are becoming more detailed and regionally-specific with

respect to feedstocks, land types, land conversion options, crop productivities, etc. For example, energy elasticities have been improved, a new land cover nesting structure was introduced to separate forest from cropland and pastureland, and corn oil is now separated in the ethanol production process. Another improvement involves determination of productivity when expanding croplands into forest and pastureland. Previously, a single value was used for productivity of new crops compared to existing crops (ETA value); now a process-based biogeochemistry model is used to calculate different ETA values according to agricultural ecological zone (AEZ) and geographic location. As a result of these and other improvements, the predicted amount of LUC required to support biofuels growth has decreased from a value of 0.22 Ha/1000 gal in 2010 to 0.11 Ha/1000 gal in 2013 (both figures from Tyner's group). Tyner also presented data showing good correlation between harvested hectares and crop prices. Substantial increases in crop areas have occurred over the past decade, with almost all of this occurring outside of Europe and North America. Tyner concluded by explaining that in addition to uncertainties in determining the amount and location of iLUC, there is considerable uncertainty in land use emission factors used to calculate the overall GHG impacts of LUC.

Debo Oladosu (Oak Ridge NL) described use of a dynamic general equilibrium model to investigate iLUC implications of US biofuels policy. This model, called GTAP-DEPS (Dynamic Energy Policy Simulator) includes fossil fuel supply curves, and operates in a dynamic fashion over the period of 2001-2030; as opposed to the standard GTAP model, which is static for a particular year. Use of GTAP-DEPS predicts that the amount and type of LUC both change over this 30-year period. Initially, global LUC is positive, at 0.17 Ha/1000 gal of biofuel; but this decreases with time, becoming negative, at -0.13 Ha/1000 gal in 2018. This contraction results largely from assumptions of increased agricultural land efficiency and income effects of the biofuels policy.

David Laborde (IFPRI) described LCA modeling to evaluate the impacts of EU biofuel policy, using an updated version of the MIRAGE-Biof model. This is a global, dynamic, computable general equilibrium (CGE) model used to estimate changes in commodities, land use, and GHG emissions in response to changes in biofuels demand. Some of the recent changes made to this model since its inception in 2008 include improved sector disaggregation, improved accounting for co-products from ethanol and biodiesel production, treatment of crops and land use at the AEZ level, and others. Laborde presented several examples to illustrate the sensitivity of model outputs to a range of EU biofuel scenarios and input assumptions. With respect to first generation biofuels over a 20-year horizon, ethanol (from various feedstocks) can satisfy the goal of 50% reduction in life-cycle GHG emissions, while biodiesel (from various feedstocks) cannot satisfy this goal. The iLUC emissions associated with ethanol pathways were approximately 10 g CO_{2-eq}/MJ, while those associated with biodiesel were approximately 50 g CO_{2-eq}/MJ. It was pointed out that although large amounts of land are needed to produce fuels that satisfy EU biofuel policies, relatively little new land is required. Sensitivity analyses showed very similar results, whether or not Europe instituted trade liberalization policies with respect to biofuels. Consideration of 2nd generation biofuels (from crop residues and dedicated energy crops) introduces many new options and uncertainties. Laborde presented preliminary modeling results for ethanol from wheat straw and corn stover that estimated very low iLUC emissions of about 4 g CO_{2-eq}/MJ.

Sonia Yeh (UC-Davis) described opportunities to employ model collaboration for improved assessment of biomass supplies and biofuels impacts. She began by defining four categories of modeling approaches currently being used: (1) economic computational general equilibrium, (2) partial

equilibrium, (3) biophysical/economic engineering, and (4) integrated assessment. Each category has particular strengths and limitations. The objective of collaboration among these models is not to determine which approach is best, but to exploit the strengths of different approaches, thereby determining an overall better assessment of biomass and its impacts. Model collaboration can involve differing levels of engagement – from simple harmonizing of input data and scenarios, to complex integration by which inputs and outputs from one model drive (and are driven by) another model. Yeh presented three examples of where model collaboration can improve understanding and better address existing problems affecting LCA of biofuels:

1. Livestock production and its effects on availability of land and biomass feedstocks
2. Availability and use of agricultural and forest residues for bioenergy
3. Determining location, amount, and impacts of LUC that is induced by bioenergy policy

In a specific case, Yeh discussed modeling approaches to assess options for further development of biofuel feedstocks in Brazil. Incorporation of non-economic drivers in modeling (e.g., socio-economic and biophysical drivers) along with policy enforcement scenarios provides a basis for determining acceptable options for such development.

Stefan Unnasch (Life Cycle Associates) discussed a project he is currently conducting under sponsorship of the CRC, called Project E-88-3. The objectives of this project are to explain the structures and functions of models commonly used to assess LUC impacts of biofuels, and to compare/contrast the important drivers that affect LUC predictions. The four models included in this study are:

1. FASOM: Forest and Agricultural Sector Optimization Model
2. FAPRI: Food and Agricultural Research Institute model
3. GTAP: Global Trade Analysis Project
4. MIRAGE-Biof: Modeling International Relationships in Applied General Equilibrium

Unnasch described the general attributes of each model (general vs. partial equilibrium, geographic coverage, land cover type, time frames, land assumptions, etc.) as well as the approach used by each model in responding to a biofuel shock. No final results were presented, as the E-88-3 project is still underway. However, some of the parameters that are most influential in determining LUC estimates were identified, as shown below:

- Type and size of biofuel shock; also single vs. cumulative shocks
- Selection of land cover types – especially the amount of forest land
- Elasticities of crop supply/price and land substitution
- Biorefinery yields and co-products

Keith Kline (ORNL) discussed activities underway by the International Organization for Standardization (ISO) to develop “Sustainability Criteria for Bioenergy,” (ISO 13065). The purpose of this proposed standard is to provide a more consistent basis on which to assess the sustainability of bioenergy. A Project Committee, called PC 248, is working to develop the detailed content of this proposed ISO standard. PC 248 consists of four Work Groups, which are addressing different aspects of sustainability criteria for bioenergy:

- WG1: cross-cutting issues – including terminology, traceability, and comparability

- WG2: GHG issues – including assessment methodologies and LCA approaches
- WG3: principles, criteria, and indicators of bioenergy sustainability
- WG4: indirect effects of bioenergy

The methodologies for assessing GHG emissions and carbon footprints of products are largely based on existing ISO standards 14040 and 14044. Dealing with indirect effects of bioenergy has been controversial, with no consensus yet emerging. At this point, the WG4 has concluded that: (1) the science on indirect effects is nascent and rapidly evolving, (2) model results are inconsistent and contradictory, and (3) iLUC is incompatible with a science-based International Standard designed to generate replicable results. A Project Committee draft report has been issued and reviewed. A revised version of this Committee report is expected in April, 2014. The next step would be development of a Draft International Standard (DIS). Lacking adequate support for this, development of an ISO Technical Specification may be pursued instead.

Richard Plevin (UC-Davis) presented an updated version of the GHG emissions model and underlying carbon stock database developed for CARB to estimate iLUC emissions associated with biofuels. A major improvement is finer disaggregation of carbon data to 245 countries x 18 AEZs. This allows for subsequent aggregation to match the 134 GTAP-8 regions, or other aggregation schemes. Another improvement is separate treatment of managed and unmanaged forest lands, in contrast to GTAP's uniform treatment, which overestimates GHG emissions from managed forests and underestimates the emissions from natural forests. The GHG emission model has also been improved in its treatment of N₂O, and in assessment of long-term sequestration of carbon in harvested wood products (HWP). The updated AEZ-emission factor model has now been developed in the Python programming language, which facilitates operation on large-scale computer clusters. Plevin presented examples of Monte Carlo simulations of the joint GTAP/carbon accounting model to investigate the model's sensitivities to various inputs. The overall iLUC GHG emissions for biofuels fall between 15 and 42 g CO_{2-eq}/MJ (95% confidence interval) with a mean value of 27 g CO_{2-eq}/MJ. Of the numerous parameters investigated, economic factors within GTAP (such as price-yield elasticities and land conversion options) were the largest contributors to overall variance.

Jerry Hatfield (USDA) presented (by phone) a discussion of N₂O emissions from agricultural soils, and efforts to monitor and mitigate these emissions. Better understanding of N₂O emissions is of considerable interest because of (1) the significant contribution of N₂O to total life-cycle GHG emissions of biofuels, (2) the relatively large variability and uncertainty of these emissions, and (3) the good potential to mitigate these emissions through land/agricultural management decisions. Hatfield described both soil-based and atmosphere-based methods for measuring N₂O emissions, and discussed the advantages and limitations of both. A complete understanding of N₂O from soils is difficult because these emissions are influenced by numerous factors – including soil type, moisture level, fertilizer type and application rate, crop type, and others. High temporal and spatial variability compound the problem. Data collected as part of a USDA Agricultural Research Service (ARS) program called GRACEnet (Greenhouse gas Reduction through Agricultural Carbon Enhancement) were presented and discussed. It is clear that N₂O emissions are influenced by soil water content, with spikes in N₂O flux observed to correspond with rainfall events. Seasonal/annual measurements were also compared with model-predicted values under different land management and crop rotation regimes. Measured N₂O fluxes (expressed as kg N₂O-N/ha) were much higher than those estimated using IPCC methods (especially the

IPCC Tier 1 method). These differences were attributed in large part to the overall wetter conditions that existed during the GRACEnet program (in the US Midwest) than anticipated in the IPCC methodology.

Robert Edwards (JRC) described the development and use of JRC's Global Nitrogen Oxide Calculator (GNOC) in assessing life-cycle GHG emissions of biofuels attributed to N₂O. For most agriculturally-derived biofuels, the contribution of N₂O to total GHG emissions is large, but highly uncertain. While it is convenient to use the IPCC Tier 1 methodology to calculate N₂O emissions as part of a biofuels LCA study, the IPCC approach was intended only to provide national-level inventory reporting under the Kyoto Agreement. IPCC Tier 1 only considers fertilizer nitrogen inputs when calculating annual N₂O emissions, ignoring known effects of soil and climate. The GNOC is an on-line tool that can be used to estimate soil N₂O emissions from crop cultivation anywhere in the world. It is based on the same database of empirical N₂O measurements as the IPCC Tier 1 approach, but it considers several more input variables that influence N₂O emissions, such as crop type, soil type, and climate properties. Consequently, it is much more reliable for smaller geographic areas, and for assessing impacts of mitigation measures. When averaged over a large region, results of GNOC are consistent with IPCC. JRC has used the GNOC tool to estimate N₂O emissions from several biofuel pathways. Edwards presented examples of N₂O from soy-based biofuels originating in Argentina, USA, Canada, and China. In most cases, measured N₂O emissions were much higher than estimates from GNOC, but were in closer agreement after adding the nitrogen contribution from below-ground residues, which is not included in the IPCC protocol for national-level inventory reporting..

Summary, Information Gaps and Data Needs – Session 3 highlighted several advancements that are occurring in LCA modeling of fuels. Increased spatial and temporal resolution of data inputs are leading to improved assessments of LUC, although further improvements in these areas are still required. A greater understanding of factors responsible for iLUC, and resulting GHG impacts, is developing, although significant uncertainties remain. Soil N₂O emissions from biofuel-related agricultural activities continue to be an area of high uncertainty, although improvements have been made in reducing this uncertainty. A greater degree of model integration and collaboration is being pursued to improve overall assessments of biofuel LCA, although more needs to be done in this area too.

Session 4: Advances in LCA of Petroleum/Alternatives

Chairpersons: Phil Heirigs (Chevron), David Lax (API), Heather MacLean (Univ. of Toronto), and Michael Wang (Argonne)

Session 4 addressed advances that have been made with respect to LCA of petroleum and other non-biofuel alternatives. The four presentations in this session focused on GHG emissions associated with oil production and refining (both conventional oil and oil sands), GHGs associated with natural gas production (including hydraulic fracturing), and LCA assessments of fuels used in future vehicle technologies.

Highlights and Key Learnings:

Adam Brandt (Stanford University) discussed development of the Oil Production Greenhouse gas Emission Estimator (OPGEE), which is an engineering-based, open-source LCA tool for estimating GHG emissions from oil production operations. This includes emissions from the production, surface

processing, and transport of petroleum from the well-to-refinery (WTR). OPGEE was developed – and is still being enhanced – to determine CI values for petroleum-derived fuels as part of California’s LCFS regulations. GHG emissions vary widely from one oil field to another, and are affected by many operational parameters, such as water/oil ratios, gas/oil ratios, enhanced oil recovery measures, depth of well, and others. The most important driver is flaring – both flaring rate and flaring efficiency. OPGEE has been used to calculate a CI value for baseline gasoline used in California. To do this, 270 crude oil producing fields and crude blends were modeled. Results showed CI values ranging from below 2 to above 30 g CO_{2-eq}/MJ, with a California production-weighted value of 11.4 g CO_{2-eq}/MJ. (The GREET national average default value is 6.9 g CO_{2-eq}/MJ.) Brandt is currently comparing OPGEE with other LCA models, and is expanding the application to a broader range of oil fields.

Joule Bergerson (Univ. of Calgary) described on-going work within the Alberta project called LCA for Oil Sands Technology (LCAOST). The overall objective of this project is to improve scientific understanding of the life-cycle implications of current and developing oil sands technologies, to support choices about future natural resource investments, and drive future research and development activities. The GreenHouse gas emission Oil Sands Technology (GHOST) model has been developed and applied to estimate emissions associated with the recovery, extraction, and upgrading of oil sands resources. This Excel-based software tool is optimized for the Alberta Oil Sands Region. It characterizes life-cycle energy use and GHG emissions associated with existing oil sands technologies – not future technologies. GHOST model results shown for various scenarios indicated well-to-wheel (WTW) CI values of approximately 90-115 g CO_{2-eq}/MJ gasoline. As part of the LCAOST Project, a new refinery model was also developed, as refining of oil sands-derived crude oil was not adequately represented by previous LCA models. Results from application of this new model showed CI values (for the refining component) of approximately 4-14 g CO_{2-eq}/MJ crude oil.

David Allen (Univ. of Texas at Austin) described recent experimental measurements of methane emissions associated with natural gas production at sites involving hydraulic fracturing. This study, which was sponsored by a consortium of environmental groups and natural gas producers, sampled 190 on-shore natural gas sites in four broad locations: Appalachia, Rocky Mountains, Midcontinent, and Gulf Coast. These sites included 150 routine production well sites (489 individual wells), 27 wells with completion flowback, 9 liquid unloading events, and 4 well workovers. Results showed that at the routine production wells, emissions from pneumatic controllers and equipment leaks were somewhat higher than EPA’s natural gas emissions projections; however, completion flowback emissions were lower than previously estimated by EPA. Emissions from liquid unloading were highly variable, with 4 of the 9 measured unloadings being responsible for 95% of the total emissions. Allen concluded that more sampling and measurements of liquid unloading is necessary to properly account for this category of methane emissions. Assuming the measurements made in this study are representative of the national situation, a total inventory of methane emissions from natural gas production was calculated to be 2.3×10^3 Gg/yr. This is in good agreement with EPA’s most recent inventory (2011) figure of 2.5×10^3 Gg/yr, but is considerably lower than EPA’s prior (2010) inventory figure of 6.0×10^3 Gg/yr.

Heiko Maas (Ford Motor Company) presented updates to JEC’s well-to-wheels (WTW) GHG assessments of light-duty European vehicles. The first WTW study was completed in 2004; Version 4 will be completed by the end of 2013. For the tank-to-wheel (TTW) component, the vehicle platform has been updated from 2002 to 2010, with projections for future configurations in 2020. The propulsion

systems have been expanded to include a number of hybrid and electric concepts. The New European Driving Cycle (NEDC) was applied to gasoline vehicles, and the UNECE R101 cycle was applied to the electrified vehicles. On the well-to-tank (WTT) side, updates have been made to fuel pathways, soil N₂O emissions have been improved, and the European electrical grid has been updated. Maas presented a few draft results of full WTW GHG emissions for several cases with both 2010 and 2020 vehicles. In the 2010 case, the highest emissions came from gasoline spark ignition (SI) vehicles, at 175 g CO_{2-eq}/km. SI vehicles fueled with CNG and LPG both had WTW emissions levels of approximately 150 g CO_{2-eq}/km, as did diesel compression ignition (CI) vehicles. Plug-in hybrid electric vehicles (PHEV) and range-extended electric vehicles (REEV) had emissions of approximately 110 and 100 g CO_{2-eq}/km, respectively. Full battery electric vehicles (BEV) had GHG emissions of 75 g CO_{2-eq}/km, assuming the electricity came from the 2009 European electric power mix. All of these life-cycle WTW emission levels are reduced by about 30% in 2020, due largely to assumed improvements in powertrain efficiency.

Summary, Information Gaps and Data Needs – Session 4 emphasized that LCAs of biofuels need to be viewed within the broader context of other fuels and energy sources used to establish baselines for comparison. Conventional gasoline and diesel fuel are usually considered reference points for determination of a biofuel's lifecycle GHG impacts, but there are significant uncertainties and variabilities in these reference points. GHG emissions associated with production of oil and gas are beginning to be defined with greater detail. This has revealed CI results that vary with the specific resource and technology being used. The expanding application of hydraulic fracturing has increased interest in better quantification of methane emissions associated with natural gas production. While initial measurements appear to agree reasonably well with the latest EPA inventories, additional work is necessary to characterize emissions from certain activities – particularly “liquid unloading” events, which can have large, but highly skewed emissions distributions.

Open Forum Discussions

Two Open Forum Discussion Sessions were held to further engage all participants in discussion of topics of specific interest. Both sessions were moderated by S. Kent Hoekman of the Desert Research Institute (DRI), with assistance from the Session co-chairs, John DeCicco (Univ. of Michigan) and Jeremy Martin (Union of Concerned Scientists). During both sessions, free-flowing discussions touched on many topics. Some of the main points covered are combined and summarized below.

- There was considerable discussion regarding the rapid pace of development in LCA of fuels. Concerns were expressed that major business decisions based upon today's understanding may be jeopardized by later changes in LCA requirements and results. Some thought it best to wait for the science of LCA (and especially iLUC) to “settle down” before getting locked-in to a particular approach. Others expressed the need and benefits of moving forward with LCA regulations, even though significant uncertainties may exist. Some argued that regulatory policies are always fraught with uncertainty, but this should not be a reason for inaction.
- It was discussed that different biofuel regulations have different purposes, hence the difficulty (or impossibility) of achieving total harmonization. Some regulations are focused only on GHG reductions, while others are also concerned with use of renewable resources, rural development, carbon intensity, and other issues. This leads to different “scoring systems,” some

of which include political factors, not just scientific factors. Some thought that the LCFS approach may be the most “fuel neutral,” as it is strictly focused on GHG reductions by means of CI control.

- The topics of variability and uncertainty received considerable discussion. Some emphasized the importance of distinguishing between modeling uncertainty, which may be reduced by better/more information (reducible uncertainty) and system variability, which may be an unchangeable reality of diverse fuel pathways.
- There was some consensus about the importance of evaluating and reporting the variability and uncertainty of LCA studies. Several indicated the merits of conducting formal uncertainty analyses (Monte Carlo or other techniques) to better understand the range, or probability of results. How to incorporate this information into a regulatory setting is not clear.
- Some emphasized the need to blend LCA science and policy together in a way that creates a workable global approach. Perhaps current LCA methods are (or will become) workable in Europe and North America, but what about China and India, which will eventually dominate the motor vehicle market. The size of biofuels programs, and the rate at which they are implemented, are also important.
- Several participants emphasized the importance of having a simple process for LCA of fuels. If it becomes too complex, many loopholes will develop, which will diminish the effectiveness of the program. Some thought that defining a specific CI value for a particular fuel pathway implies more certainty than warranted. Perhaps it would be better (and simpler) to develop a broad ranking of fuel pathways, and combine those that have similar CI values into common “bins.” Others pointed out that there will always be controversy about those cases that are “close to the line” that separates one bin from another.
- During the 2nd Open Forum Discussion, results from an opinion survey of the participants were presented as a way to foster further discussion of LCA-related topics. A wide diversity of opinions was apparent. With respect to the overall concept of LCA for fuels, there was general agreement that LCA approaches can provide results that are qualitatively useful, but there were mixed opinions about the quantitative reliability of these approaches in a regulatory sense. With respect to iLUC issues, most respondents believe the concept of iLUC has become better defined, understood, and accepted. However, opinions were mixed as to whether current modeling approaches provide reliable assessments of GHG emissions resulting from iLUC.
- Survey questions regarding LCA of transportation fuels were also posed in three general categories:
 1. Degree of progress (in specific LCA technical areas) over the past few years
 2. Need for further improvement in specific areas
 3. Priority areas requiring additional work

Of the 12 specific areas identified under category 1 above, the degree of progress was deemed highest in co-product allocation and evaluation of feedstocks and processing pathways. The degree of progress was judged lowest in harmonization of LCA methods and data to support fuels LCA. The need for further improvement was deemed highest for reliability of LUC

assessments, and assessments of iLUC emissions. With respect to prioritization of areas for further work, many areas were regarded as being of high priority. Among the highest priority items were (1) increase harmonization of different data sets to support LCA, (2) improve quantification of LCA uncertainty/variability, and (3) reduce the uncertainty of iLUC assessments.

Overall Workshop Summary

There was no final session to summarize the overall workshop and identify the most important take-home messages. However, given below are a few common themes that emerged, and conclusions where there appeared to be some degree of consensus.

- Considerable progress has been made during the past two years (since the previous workshop) in LCA of transportation fuels. Significant updates have been made to several of the models and underlying databases that are used in these assessments, resulting in a higher degree of confidence in model outcomes. However, despite these improvements, many of the uncertainty problems highlighted in previous workshops still remain.
- There appears to be increasing acknowledgement that different LCA modeling approaches have been developed for different purposes. Consequently, there is less call for harmonization of the models. However, there remains strong interest in clear definition of model inputs, and transparent applications of the models.
- The issue of co-product allocation, while clearly important, did not receive as much attention as in previous workshops. This now appears to be regarded as just one of many influential differences among various modeling approaches. As with all important modeling inputs, the method of co-product allocation being used needs to be clearly stated and transparently applied when performing LCA studies.
- Considerable work is now being conducted to investigate reasons for disparate results from different LCA studies. Significant progress has been made in determining sensitivities of model outputs to changes in model inputs. This is improving understanding of the strengths and limitations of different approaches, and is helping to identify area where more reliable data would be most useful.
- The topics of model variability and uncertainty continue to receive much attention. Increasing application of formal uncertainty analysis techniques is occurring, and is providing a more complete understanding of LCA model results in the form of probability distributions. Translation of these approaches into a regulatory context is still unclear.
- Considerable improvements appear to be happening in the area of LUC assessment. Greater spatial resolution now exists (in some locations) with respect to feedstocks, land types, crop productivities, and land conversion options. Overall, it appears that the extent of land use change to support biofuels policies is not as large as was thought a few years ago, although this remains an area of high uncertainty.
- The topic of indirect land use change (iLUC) remains controversial – both in principle and in application. In fuel regulatory applications, iLUC is still considered only in the US, although the

EU (and other regions) continue to study the issues, and may implement iLUC-based regulations in the future. Largely as a consequence of improved LUC modeling (and other modeling enhancements mentioned above), the impact of iLUC on the total life-cycle carbon intensity of most biofuels does not appear to be as large as thought a few years ago, but still remains a significant and uncertain parameter.

- Soil-based emissions of nitrous oxide (N_2O) are an important contributor to the total CI of some biofuels, and a significant source of overall uncertainty. Data limitations still prevent use of process-based biogeochemical models to estimate N_2O in many situations. However, a Global Nitrogen Oxide Calculator (GNOC) has been developed, which applies a higher spatial resolution than the simple IPCC Tier 1 N_2O approach.
- A better understanding of baseline CI values of fossil fuels is evolving. This is driven by more complete depictions of oil and gas production processes, and by better emissions data for these process steps. The rapid growth in hydraulic fracturing has increased concern about methane emissions associated with certain production activities, leading to more study in this area.

APPENDIX I

Glossary of Terms Used During the Workshop

AEZ	Agricultural Ecological Zone
ALCA	Attributional Life Cycle Assessment
API	American Petroleum Institute
BC	British Columbia
CARB	California Air Resources Board
CARD	Center for Agricultural and Rural Development
CCLUB	Carbon Calculator for Land Use change for Biofuels
CGE	Computable General-Equilibrium
CI	Carbon Intensity; also Compression Ignition
CLCA	Consequential Life Cycle Assessment
CNG	Compressed Natural Gas
CO ₂	Carbon Dioxide
CO _{2,eq}	Mass of a specified GHG expressed as a mass of CO ₂ having equivalent GWP
CONCAWE	CONservation of Clean Air and Water in Europe
CRC	Coordinating Research Council
DEPS	Dynamic Energy Policy Simulator
DNDC	De-Nitrification De-Composition (model for N ₂ O emissions)
DOE	U.S. Department of Energy
DRI	Desert Research Institute
EC	European Commission
EER	Energy Efficiency Ratio
EF	Emission Factor
e-GRID	Emissions & Generation Resource Integrated Database
EIO-LCA	Economic Input-Output- Life Cycle Assessment Model
EOR	Enhanced Oil Recovery
EPA	(US) Environmental Protection Agency
EU	European Union
EV	Electric Vehicle
ExioBase	Multi-regional supply and use input/output database
FAME	Fatty Acid Methyl Ester (biodiesel)
FAO	Food and Agricultural Organization
FAPRI	The Food and Agricultural Policy Research Institute
FASOM	The Forest and Agricultural Sector Optimization Model
FORCARB	U.S. Forest Carbon Budget Model
FQD	Fuel Quality Directive
g CO _{2,eq} MJ ⁻¹	grams of CO ₂ , equivalents per MJ of fuel
GEMIS	Global Emission Model for Integrated Systems
GHG	Greenhouse Gas
GHGenius	LCA model used in Canada
GHOST	Green House gas emission Oil Sand Technology (GHG emissions model)
GLOBBIO	Global Biomass Optimization Model
GNOC	Global Nitrogen Oxide Calculator
GRACE	Greenhouse gas Reduction through Agricultural Carbon Enhancement
REET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model

GTAP	Global Trade and Analysis Project
GWP	Global Warming Potential
HCICO	High Carbon Intensity Crude Oil
HDRD	Hydrogenation-Derived Renewable Diesel
HWP	Harvested Wood Products
HWSD	Harmonized World Soil Database
IAM	Integrated Assessment Model
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
ILUC	Indirect (or Induced) Land Use Change
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JEC	JRC, EUCAR and CONCAWE
JRC	(EC) Joint Research Centre
LCA	Life Cycle Assessment
LCAOST	Life Cycle Assessment of Oil Sands Technologies
LCFS	Low Carbon Fuel Standard
LEM	Life Cycle Emissions Model
LHV	Lower Heating Value
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LUC	Land use change
MIRAGE	Modeling International Relationships in Applied General Equilibrium
MODIS	Moderate Resolution Imaging Spectroradiometer
MOVES	Motor Vehicle Emission Simulator (EPA model)
N ₂ O	Nitrous Oxide
NBB	National Biodiesel Board
NPV	Net present value
NREL	National Renewable Energy Laboratory
OPGEE	Oil Production Greenhouse gas Emission Estimator
PEF	Product Environmental Footprint
PHEV	Plug-in Hybrid Electric Vehicle
RED	Renewable Energy Directive
REEV	Range Extended Electric Vehicle
RFS2	Renewable Fuels Standard
SCAQMD	(California) South Coast Air Quality Management District
SI	Spark Ignition
SOC	Soil Organic Carbon
SSA	System Sensitivity Analysis
TEM	Terrestrial Ecosystem Model
TTW	Tank-to-Wheels
USDA	U.S. Department of Agriculture
WTW	Well-to-Wheels
WTR	Well-to-Refinery
WTT	Well-to-Tank

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Panel Previews

The Algae Fuel Solution - Updates from Algenol Biofuels, Sapphire Energy and Cellana

Thursday, October 3 | 8:45 am - 9:30 am

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Moderator:

Tim Portz

Executive Editor, Biomass Magazine

Paul Woods

CEO, Algenol Biofuels

Cynthia "CJ" Warner

CEO & Chairman, Sapphire Energy Inc.

Martin Sabarsky

CEO, Cellana

Beyond Fuel - Updates on Feed, Nutrition, and Specialty Chemicals and Products

Thursday, October 3 | 9:30 am - 10:15 am

Moderator:

Jim Lane

Editor & Publisher, Biofuels Digest

Tim Burns

President, BioProcess Algae

Dan Simon

President & CEO, Heliae

Mike Van Drunen

CEO & Founder, Algix LLC

Greg Bafalis

CEO, Aurora Algae

Keynote Address

Thursday, October 3 | 10:45 am - 11:15 am

Moderator:

Matt Horton

CEO, Propel Fuels

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Panel Previews

Fuel Production Innovation

Tuesday, October 1 | 2:30 pm – 4:00 pm

This panel examines the RFS drivers behind fuel production, successful large-scale cultivation, harvesting, and processing for fuel production, and several technologies for processing algae oil and algae biomass to fuels.

Panel Chair:

Michael Lakeman

The Boeing Company

Mary Solecki

E2 (Environmental
Entrepreneurs)

*How the Low Carbon Fuel
Standard is driving growth in algal
fuels*

Hoyt Thomas

OpenAlgae
*Integrated Algae Growth with
PCM and Solventless Oil
Recovery Process Demonstrated*

Rebecca White

Sapphire Energy Inc.
*Sapphire Energy's Green
Crude Farm – Year in
Review*

Pat Leung

CRI Catalyst Co.
*Advances in Algal Biomass
Conversion Technologies*

Biomass Production Innovation

Tuesday, October 1 | 4:30 pm – 6:00 pm

This panel examines innovation in biomass production from the pilot-scale through large-scale cultivation including various approaches to cultivation, economic modeling, and some international perspective.

Panel Chair:

Ira "Ike" Levine

Algae Foundation

Amit Vasavada

General Atomics
*Large-scale Algae
Cultivation for Protein*

Schonna Manning

The Culture Collection of Algae (UTEX)
Managing Microalgae at the Pilot-Scale

Adrian Galvez

Heliae
*Achieving Commercial Viability with Mixotrophy:
Proving Scalability and Economics in Gilbert, AZ*

Production

Dil Vashi

Solutions4CO2 Inc.
*Enhancing the Economic
Model of Algal Bio-
Products*

Ji-Won Yang

KAIST & Advanced Biomass R&D Center
*The National Policy, Investment, and Directions of
Microalgae-Based Biofuels and Bioproducts
Research and Development in Korea*

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Panel Previews

Commercializing Value-Added Products

Wednesday, October 2 | 11:00 am – 12:30 pm

This panel examines industry developments in deploying algae as a platform for high-value commodity products, the use of different feedstocks, end products, and technology innovations.

Panel Chair:
Toby Ahrens
BioProcess Algae

Pradeep Sharma
Algenol Biofuels
*Anthropogenic CO₂ as
a Feedstock for
Cyanobacteria-Based
Biofuels*

Pieter Boelens
Evodos
*Evodos@work: High
Quality Output of Algae
Paste Makes the
Difference*

Ryan Hunt
Algix LLC
*Commercialization of Algae-blended
Thermoplastics and Feedstock Supply
Chain*

Lee Tonkovich
Heliae
*Good Science = Scale: Leveraging Sound
Science and Innovation for Algae Product
Development and Commercialization*

Commercializing Specialty Products

Wednesday, October 2 | 1:30 pm – 3:00 pm

This panel examines industry developments in deploying algae as a platform for high-value specialty products, emerging opportunities in agriculture, market dynamics, and sustainable operations.

Panel Chair:
Mark Allen
ABO

Wenguang Zhou
University of Minnesota

Emily Trentacoste
UC-San Diego
*The Place of Algae in Agriculture: Where It Is,
Where It Should Be, and How to Get There*

Emilie Slaby
The Scoular Company

Innovative Waste-to-Algae Technologies for Sustainable and Environment-enhancing Biofuel and Biobased Byproduct Production

Brian Goodall,
Valicor Renewables
Commercialization of New Algae-based Omega-3 Supplements with High Bioavailability

Protein Feed Market Dynamics and What They Mean for the Algae Meal Producer

Greg Sower
ENVIRON International Corp
Shifting Focus from Fuels to Foods: How to Enter the Food, Feed, and Nutraceutical Markets

[View Agenda](#) [View Track Panels](#)

Industry Tours:

Seating is Limited – Register Now

Monday, September 30

8:30 am – 4:00 pm

Daytona International Speedway and Kennedy Space Center

The tour begins at the Kennedy Space Center Visitor Complex where attendees will have an opportunity to view the Space Shuttle Atlantis, which until this summer was not available for viewing. Additionally, attendees can participate in the Shuttle Launch Experience, view the Apollo/Saturn V Center and spend time in the complex gift shop.

The Daytona International Speedway will welcome tour attendees for lunch and an afternoon learning about this storied racing facility. Tour guides will provide attendees with walk through tours of the drivers meeting room, NASCAR Sprint Cup Series garage areas, Gatorade Victory Lane and a lap around the super speedway. This tour provides conference attendees with an excellent networking opportunity set in two of the Orlando area's most popular attractions.

Limited Spots

[Register for Industry Tours](#)

Exhibit at the Largest Gathering of Algae Professionals in the World!

Now's the Time to Register for Your Premium Expo Booth

The expo hall continues to be a valuable and popular meeting place for algae professionals attending the event. Last year marked the third consecutive year the hall sold out. The expo hall's popularity is attributed to the fact that it receives a high amount of visitor traffic from networking receptions, breaks and meal functions taking place in the expo hall space. A limited number of exhibits are available—so reserve your spot today!

Exhibit Booth Includes

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- Two complimentary full conference registrations
- Company listing on the conference website
- Company listing in the on-site program
- Company mention in promotional e-mails and brochures
- One 8' x 10' (foot) booth and company identification sign

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[Become an Exhibitor](#)

Your peers are saying...

*"The **Algae Biomass Summit** provides an outstanding opportunity for emerging algal businesses, customers, and supply chain partners to discuss potential business endeavors."*

- Joel Murdock, FedEx Express

*"The **Algae Biomass Summits** are always a phenomenal networking opportunity and industry news platform very well worth attending. The venues entail scientific, commercial, legal and global algae awareness content that cannot be replaced in any other format."*

- Andre Harvey, Colorado Lining International

"This is absolutely the best conference of this kind and it offers great opportunities for networking, interaction, collaboration while learning the latest scientific breakthroughs and technological innovations in algal biotechnology and commercialization."

- Qiang Hu, Arizona State University

"This algae show only gets better and better year after year with more and more qualified attendees."

- Keith Funsch, GEA Westfalia Separator

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